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Description

The present invention relates to improvements in out-of-balance controls for laundry machines or the like.

Laundry machines having a rotatable, perforated cylinder, or drum, are well known for both commercial and domestic use. The drum is disposed within a housing and may be disposed on a vertical or horizontal axis, the latter being more typical of laundry machines for commercial use.

After fabric goods, or the like, are loaded into the drum, a main control may be actuated. Such controls program the operation of the various mechanisms comprising the laundry machine. While there are many variations, typically there will be a wash cycle, a spin cycle involving rotation of the drum for extraction of liquid by centrifugal force, a rinse cycle and a further spin cycle.

In machines where the drum rotates about a vertical axis, an agitator is generally provided and typically oscillates to facilitate the washing action. In machines where the drum rotates about a horizontal axis, generally, the drum rotates at a relatively low speed so that the fabric goods are tumbled to provide agitation for facilitating the washing action.

It is a well recognized problem that extreme vibration of these machines will be produced if the wet goods are not evenly distributed about the axis of the drum when it is accelerated to the high speeds employed in the spin cycle. Such load unbalance conditions can cause out-of-balance, centrifugal forces which, under worst case conditions, can cause the drum the break free from its mountings. Even moderate out-of-balance loads will cause vibrations which significantly reduce the service life of the bearings and other components of the machine.

These problems are exacerbated in commercial laundry machines, where the drum is mounted for rotation about a horizontal axis. Drum diameters can be as great as 1,12m (44 inches), or more, with washing load weight in the order of 62,5 kg (125 pounds). In the wash cycle, a relatively low rate of rotation is employed. The final spin speed of the drum, for liquid extraction generates centrifugal forces several times the force of gravity. With these extreme speeds, the criticality of a load unbalance becomes more acute. In recognition of this fact, it is an accepted practice to first accelerate the drum to a distribution speed wherein the centrifugal force generated by the load approximates two "g's". The drum is thereafter accelerated to the higher, liquid extraction speed where centrifugal forces approaching 300 "g's" are generated.

Many solutions have been proposed for this problem. Primarily these solutions are predicated on the use of a mechanical means to detect displacement of the drum to sense displacement of the basket due to an unbalanced load. Usually this involves the use of a switch which actuates means for reducing the rate of drum rotation. In some cases the motor is shut down to permit manual redistribution of the load. In other cases, the control will reduce the drum speed to permit the load to redistribute itself and then automatically reaccelerate the drum, in the expectation that a balance has been achieved.

One of the problems in the use of switches is a lack of sensitivity. That is, a fairly high magnitude of drum displacement is required to actuate the switch. Relatively high forces may thus be generated before a speed reduction occurs to remove the stresses on the rotor bearings and other components of the machine. This is further complicated by the fact that switches are vulnerable to malfunction as a result of vibrations. They are, thus, not as reliable as would be desired.

A further problem, also related to sensitivity, is that the sensing means are not responsive to load unbalance conditions until the drum has reached its relatively high, spin speeds, where the resultant centrifugal forces are at a level which will cause damage.

There are, additionally, limited teachings of the use of electrical means for detecting an unbalanced load condition, as found in US-A 2,917,175. To the best of applicant's knowledge there has been no commercial acceptance of other than "mechanical" detection means.

In the referenced patent, it is recognized that, motor current varies as a function of torque variations resulting from load unbalance which produce the undesirable centrifugal forces on the drum. However, it is there proposed to detect the phase shift in the current drawn by the motor as a means for detecting load unbalance centrifugal forces which cause variations in the torque required to rotate the drum.

DE-A-3416639 describes a microcomputer spin cycle control which, at a predetermined rate of rotation, begins measuring the amount of time it takes for the machine to accelerate to a specified higher rate. This occurs after the imbalance has been measured by some unspecified current or rate determining means. FR-A-2311883 and FR-A-2496136 both disclose elementary analogue circuits for determining a load imbalance. In particular, FR-A-2311883 monitors the drive motor current and if the instantaneous amplitude of this current exceeds a predetermined threshold value a load imbalance is assumed to hav occurred and the spin cycle controlled accordingly. The preamble to claim 1 is based on this citation.

According to the invention there is provided an out-of-balance control for a laundry machine including a perforated drum in which goods are placed for washing, electric motor drive means for rotating said drum, main control means, for said machine, having means for controlling said electric drive means and rotation of said drum, including means for accelerating rotation of said drum to a relatively high rate of rotation for the extraction of liquid from goods therein, by centrifugal force; means for deriving, from the electric motor drive means, a "real time" current signal proportionate to the current drawn by said motor, such current being, in turn, proportionate to the torque required to rotate the drum, the torque requirement for the motor varying cyclically in proportion to any unbalance in the load within the rotating drum and the centrifugal forces generated thereby; means for producing an "unbalance control" signal based on the magnitude of said "real time" signal; means responsive to said "unbalance control" signal for reducing the rate of rotation of said drum, to prevent damage to the machine from centrifugal forces resulting from an unbalanced load when the drum is rotating at an extraction speed; and characterised in that said means for producing an "unbalance control" signal comprises: means for averaging said "real time" signal, the time constant for said averaging means being such that the "average" signal output is proportionate to the average current drawn by the motor during a relatively few number of rotations; means for differencing said "average" signal from said "real time" signal, to provide an "unbalance torque" output signal of alternating polarity, the amplitude of which is proportionate to variations in motor torque resulting from centrifugal forces generated by load unbalance; and means responsive to the amplitude of the "unbalance torque" signal exceeding a preset magnitude (representing a maximum permissible unbalance centrifugal force), for generating said "unbalance control" output signal.

By means of this arrangement there is provided a control of improved sensitivity in detecting an out-of-balance condition which thereby minimizes the centrifugal loads, and vibrations, to which the machine is subjected. Furthermore the control senses an out-of-balance condition at relatively low drum speeds, minimizing out-of-balance loads on the machine as well as increasing the probability that a load will have the ability to properly redistribute itself, without the need for manual intervention.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings in which:-

Fig. 1 is a block diagram of a laundry machine incorporating an out-of-balance control; and

Fig. 2 is a sch matic diagram of the present out-of-balance control, broken down into its block diagram components and illustrating control signals generated therein.

The out-of-balance control, of the present invention is primarily adapted for use in laundry machines, and more particularly to washers of the type comprising a perforated drum 10 (Fig. 1) into which fabric goods, such as clothing, may be placed. The drum is disposed within a closed container into which water may be introduced for a washing cycle, which can involve agitation of the fabric goods. The water is then evacuated. Next the drum can be a rinse cycle and then a spin cycle in which the drum is rotated at high speed to extract most of the water from the fabric goods, by centrifugal action.

There are a wide variety of cycle sequences employed in washing machines, as well as a wide range of duration of the time for any individual cycle. The present invention finds particular utility in commercial washing machines wherein the drum is mounted for rotation about a horizontal axis. A washer main control, identified by reference character 12, may comprise manually operated switches for selecting a desired cycle sequence, as well as the time for a given sequence, such as the wash cycle. The control 12 may employ microprocesser circuitry which generates digital signals which are transmitted to an interface board 14 to generate analogue signals. The analogue signals provide a control input to a variable frequency drive 16, which controls a drive motor 18 for the drum 10.

The main control 12 generates the necessary signals for actuating, and sequencing, the various valves, pumps and other accessory items employed in washing machines. For purposes of the present invention, it is sufficient to understand that this control provides the input for controlling the variable frequency drive for the drive motor 18. The variable frequency drive is, likewise, a known variable speed drive means for electrical motors which, relatively recently, has enabled elimination of more cumbersome mechanical means for driving the drums of washing machines.

The main control 12, employed herein, is, preferably of a known type which causes rotation of the drum 10 at a relatively low speed during the wash cycle. For purposes of relative values, this speed would be 35 r.p.m. This speed, for a 1.12m (44 inch) diameter drum, generates centrifugal forces of approximately .7 "g", resulting in a tumbling action of the load to facilitate the washing action. When this cycle is complete (and water evacuated) the drum is accelerated to a distribution speed wherein the centrifugal forces generated approximately 2 "g's" at a speed of 60 r.p.m. After the load is stabilized at the distribution speed, the

drum is accelerated to the high speed required for liquid extraction. This may be done in steps, illustrated by spin cycle speeds of 350 r.p.m and then 700 r.p.m.

In any event, it is when the drum 10 is accelerated to these spin speeds, that an unbalance of the fabric load in the drum 10 can become a problem. To avoid this problem and prevent rotation of an unbalanced load at speeds which would generate centrifugal forces capable of reducing the useful life of the various components of the washer, an input signal is provided from the variable frequency drive 16 to an out-of-balance control 20. As will now be described in detail, the out-of-balance control 20 generates a signal input to the main control 12 which, in turn, generates a signal input to the variable frequency drive, causing a reduction in motor speed.

The variable frequency drive 16 provides a continuous input signal to the out-of-balance control 20. This input signal is a "real time" current signal, proportionate to the power drawn by the motor 18 in rotating the drum 10. It is illustrated at the bottom left portion of Fig. 2.

Figure 2 further illustrates the elements of the out-of-balance control in block diagram form. The signal forms generated by these elements are then illustrated below the respective elements of the control.

Functionally, it will be seen that the "real time", input signal to the control 20 is a variable d.c. signal. The variations in the strength of this signal are proportionate to the variations in the torque requirements for rotating the drum. When there is a load unbalance, there is a radial force of varying magnitude which results in a correspondingly varying torque requirements in rotating the drum. The magnitude of the differential between the minimum and maximum levels of the current (power) signal is proportionate to the out-of-balance, centrifugal force on the drum. The frequency of the variation in this signal strength is directly proportional to the rate of rotation of the drum 10. The average strength of the input signal is proportional to the power required to rotate the drum. That is, all things being equal, the heavier the load in the drum, the greater the power required to rotate it at a given speed.

With these factors in mind, the "real time" input signal is fed to an averaging amplifier 22, the output of which is an "average" signal having a strength reflecting the average torque, over a relatively few revolutions, for driving the drum 10.

This "average" signal becomes one input to a differential amplifier 24, the other input for which is the "real time", input signal from the variable frequency drive 16. The output signal from the differential amplifier is then an "unbalance torque" signal of alternating polarity, the magnitude of which is proportional to the variations in torque requirements r sulting from an unbalance load. This, in turn, reflects the resultant, undesirable forces to which the drum bearings and other components of the machine would be subjected.

The following means then are employed to generate an "unbalance control" signal when the load unbalance exceeds a preset limit. The "unbalance control" signal is then employed to reduce drum speed as will be more fully explained.

The output of the differential amplifier may be fed to an amplifier 26 which provides the further function of filtering out extraneous "noise", or radio (high) frequencies, in addition to amplifying the "unbalance torque" signal.

The "unbalance torque", alternating current signal is next converted to an averaged, single polarity, direct current signal by a full wave rectifier 28 and a low pass filter 30.

A reference signal generator 32 provides one input to a comparator 34. The other input to the comparator 34 is the averaged "unbalance torque" signal. The strength of the "reference" signal represents the maximum, permissible, load unbalance, centrifugal force for the machine. When the strength of the averaged, "unbalance torque" signal exceeds the strength of the "reference" signal, the "unbalance control" signal is generated and is transmitted from the comparator 34 to the main control 12. In response to an "unbalance control" signal the main control 12 provides an appropriate signal input, through the interface board 14 and variable frequency drive 16, to reduce the speed of the motor 18 and the drum 10.

It is to be noted that the level of the "reference" signal is set to be responsive to the maximum load unbalance, at the relatively low distribution speed of the drum, which does not produce unacceptable unbalance load forces on the drum, when it is further accelerated to the much higher speeds employed for liquid extraction, in the spin cycle.

In further illustration, the "real time" signal (bottom left, Fig. 2) is illustrated with a progressively increasing amplitude, illustrating an increasing centrifugal force being generated by a load unbalance as the drum is accelerated to its distribution speed. The "average" signal remains at a constant strength, being a function of load weight. The "unbalance torque" signal progressively increases in amplitude, again reflecting the increase in centrifugal force resulting from load unbalance. Note, the time increment is insufficient to reflect an increase in "average" torque, as the speed of rotation is increased.

The further amplification of the "torque unbalance" signal and its rectification and averaging

results in a progressively increasing signal strength input to the comparator 34. When the strength of this d.c. "unbalance torque" signal exceeds the strength of the "reference" signal, the "unbalance control" signal is generated and fed to the main control 12, and the speed of the drum reduced to its tumbling speed, for redistribution of the load. The main control is programmed to then reaccelerate the drum 10 to its distribution speed, with the expectation being that the load will be properly balanced for acceleration of the drum to its liquid extraction, spin cycle speeds.

The components of the out-of-balance control 20 will now be described in greater detail. The averaging amplifier circuit 24 may comprise input resistors 36, 38 across which the "real time" current signal is impressed. The voltage signal thus generated provides one input to a high gain amplifier 40. A feedback circuit comprising resistors 42, 44 and capacitor 46 filter out the pulsating portion of the power signal, to provide a signal which reflects the average power drawn by the motor 18. The time constant provided by this feedback is, approximately, the time for 3-4 revolutions of the drum 10, at its distribution speed.

The differential amplifier circuit 24 may comprise an input resistor 48 through which the "average" signal is fed to an amplifier 50. The "real time" signal is fed through input resistors 52, 54 to provide a second input to the amplifier 50. A feedback resistor 56 completes the differential amplifier circuit 24. The resistors 52, 54 function as scaling resistors, to the end that the output of the differential amplifier 24, subtracts the "real time" signal from the "average" signal. The output "unbalance torque" signal then reflects the variations in power requirement caused by load unbalance.

The RF filter/amplifier circuit 26 may comprise an input resistor 58 connected to one input of an amplifier 60, the other input of which is connected to ground. The filtering function is provided by a feedback circuit comprising a resistor 62 and a capacitor 64. The values of the feedback circuit are selected to filter out frequencies substantially greater than the 60 cycle/minute variations in signal strength proportionate to the distributional speed of the drum and, more particularly "noise", i.e., relatively high frequencies which frequently become imposed on the primary signal in high gain amplification.

The full wave rectifier circuit 28 may comprise input resistors 66, 68, providing one input to an amplifier 70, the other input of which is connected to ground. A feedback circuit is provided by diodes 72 and a resistor 74. An output resistor 76 completes this circuit.

The low pass filter circuit 30 may comprise an amplifier 78, having the pulsating d.c. output of the rectifier 28 connect d to one input, with the other input connected to ground. A feedback circuit, comprising resistor 77 and capacitor 79, provides the desired filtering action.

The reference signal generator 32 may comprise a potentiometer 80 connected to across a regulated d.c. power supply source to ground, with an adjustable, outlet tap 82. The outlet tap is adjusted to set the strength of the "reference" signal to reflect the maximum unbalance forces which are to be permitted when the drum 10 is at its liquid extraction speeds.

The comparator circuit 34 may comprise an amplifier 84 output resistor 86 and diode 88.

Selection of the several components of the out-of-balance control 20 would be within the abilities of one skilled in the art, recognizing that relatively low voltage potentials would be employed, consistent with known safety practices.

In a more specific sense, it is contemplated that the drum 10 rotates about a horizontal axis. The washer main control 18 comprises means for generating signals which, through the interface 14 and variable frequency drive 16, powers the motor to rotate the drum at a rate generating less than one "g" forces in the fabrics being washed. The materials are thus carried part way up the drum and then tumble downwardly to provide an agitation which enhances the washing action. For purposes of illustration, with a drum diameter of 1.12m (44 inches), a speed of 35 r.p.m., generating approximately .7 "g" is satisfactory.

After a preset time, the wash water may be automatically evacuated by a pump. The output signal of the main control then causes the drum 10 to accelerate, relatively slowly (8-10 seconds), to a distribution speed of 60 r.p.m., generating approximately two "g's".

In this distribution cycle, the various items of the load being washed, as a general rule, become equally distributed about the inner surface of the drum, with only minimal centrifugal forces acting to displace the drum from its axis of rapidly accelerated first to 350 rpm for a finite period, and then to 700 rpm, generating "g" forces of 70 and 280, respectively. Obviously any load imbalance, at these higher speeds, would result in "g" forces which could be destructive.

The out-of-balance control of the present invention is devised to essentially eliminate destructive centrifugal forces by detecting unbalance load conditions during the distribution cycle. When such condition is detected, the main control reduces the drum rotation to the wash or tumble speed for a finite period, and, then reaccelerates the drum speed to the distribution speed. This recycling through the distribution cycle can be repeated, as desired, and, then if an unbalanced condition per-

sists, th machine shut down for manual adjustment of the load.

The provision of means for providing the functions described in connection with the main control 12, interface 14 and variable frequency drive 16 are all within the abilities of one skilled in the art and do not require specific direction.

Claims

1. An out-of-balance control for a laundry machine including a perforated drum (10) in which goods are placed for washing, electric motor drive means (18) for rotating said drum (10),

   main control means (12), for said machine, having means for controlling said electric drive means (18) and rotation of said drum (10), including means for accelerating rotation of said drum (10) to a relatively high rate of rotation for the extraction of liquid from goods therein, by centrifugal force;

   means for deriving, from the electric motor drive means (18), a "real time" current signal proportionate to the current drawn by said motor (18), such current being, in turn, proportionate to the torque required to rotate the drum (10), the torque requirement for the motor (18) varying cyclically in proportion to any unbalance in the load within the rotating drum (10) and the centrifugal forces generated thereby;

   means for producing an "unbalance control" signal based on the magnitude of said "real time" signal;

   means responsive to said "unbalance control" signal for reducing the rate of rotation of said drum, to prevent damage to the machine from centrifugal forces resulting from an unbalanced load when the drum is rotating at an extraction speed; and characterised in that said means for producing an "unbalance control" signal comprises:

   means for averaging (22) said "real time" signal, the time constant for said averaging means (22) being such that the "average" signal output is proportionate to the average current drawn by the motor (18) during a relatively few number of rotations;

   means for differencing (24) said "average" signal from said "real time" signal, to provide an "unbalance torque" output signal of alternating polarity, the amplitude of which is proportionate to variations in motor torque resulting from centrifugal forces generated by load unbalance; and

   means (28,30,32,34) responsive to the amplitude of the "unbalance torque" signal exceeding a preset magnitude (representing a maximum permissible unbalance centrifugal force), for generating said "unbalance control" output signal.

2. An out-of-balance control as claimed in claim 1, characterized in that the means for generating an "unbalance control" signal is constituted of a means for rectifying (28) the "unbalance torque" signal to a single polarity signal and filtering (30) said signal with a time constant providing an averaged "unbalance torque" signal reflecting the unbalance torque current over a relatively few revolutions of the drum; means for generating a "reference signal", the magnitude of which represents the maximum unbalance torque load to be permitted, and means for comparing (34) the averaged "unbalance torque" signal and the reference signal and generating said "unbalance control" signal when the averaged "unbalanced torque" signal exceeds the reference signal.

3. An out-of-balance control as claimed in claim 1, characterized in that the means for averaging the "real time" signal comprise an operational amplifier (22); the differentiating means comprise a differential amplifier (24), said "real time" signal being one input thereto and the "average signal" being the other input thereto; and the means for generating an "unbalance control" signal comprises a full wave rectifier (28) and low pass filter (30) to which the alternating polarity, "unbalance torque" signal is fed to provide a direct current "unbalance torque" signal averaged over a relatively few revolutions of the drum, means for generating (32) a direct current "reference" signal having a magnitude representing the maximum unbalance torque load on the motor (18), and means for comparing (34) said reference signal and said averaged "unbalance torque" signal and generating said "unbalance control" signal when the averaged "unbalance torque" signal exceeds said "reference" signal.

4. An out-of-balance control, as claimed in claim 2 or 3 characterised in that the means for generating a "reference" signal comprise a potentiometer (82) connected to a source of fixed voltage, the output of the variable tap of the potentiometer being adjusted to provide a "reference" signal of desired strength.

5. An out-of-balance control as claimed in claim 3 or 4 characterised in that the out-of-balance control further comprises a second operational amplifier (26) interposed between the differential amplifier (24) and the full wave rectifier (28), for amplifying the "unbalance torque" sig-

nal; said second operational amplifier (26) having a filter feedback (62,64) for eliminating signals of a frequency substantially greater than the frequency of the distribution speed, from the "unbalance torque" signal.

6. An out-of-balance control as claimed in any preceding claim characterised in that the drum (10) rotates about a horizontal axis, the main control (12) and electric motor drive means (18) rotate the drum (10) at a speed generating approximately .7 "g" on the load therein, during a wash cycle, whereby the load is tumbled to facilitate washing action, then, automatically accelerates said drum (10) to a distribution speed generating a loading of approximately 2 "g's" for a limited period of time and the further accelerates rotation of said drum (10) to a speed generating a loading of several "g's" for extraction of the major portion of liquid from said load; and further characterised in that the reference signal is set to limit permissible unbalance torque to a level detectable during the initial acceleration of the drum (10).

Patentansprüche

1. Unwuchtsteuerung für eine Waschmaschine mit einer perforierten Trommel (10), in der Waschgut aufgenommen wird, einer Elektromotor-Antriebseinrichtung (18) zum Drehen der Trommel (10),
einer Hauptsteuereinrichtung (12) für die Maschine mit einer Einrichtung zum Steuern der elektrischen Antriebseinrichtung (18) und der Drehung der Trommel (10), umfassend eine Einrichtung zum Beschleunigen der Drehung der Trommel (10) auf eine relativ hohe Drehzahl, um Flüssigkeit aus dem darin befindlichen Gut durch Zentrifugalkraft auszutreiben;
eine Einrichtung zum Ableiten eines zu dem von dem Motor (18) aufgenommenen Strom im Verhältnis stehenden "Echtzeit"-Stromsignals aus der Elektromotor-Antriebseinrichtung (18), wobei der Strom seinerseits im Verhältnis zu dem Drehmoment steht, welches zum Drehen der Trommel (10) erforderlich ist, wobei das Drehmomenterfordernis für den Motor (18) zyklisch im Verhältnis zu einer möglichen Ungleichmäßigkeit in der Beladung innerhalb der sich drehenden Trommel (10) und den dadurch erzeugten Zentrifugalkräften variiert;
eine Einrichtung zum Erzeugen eines "Unwuchtsteuer"-Signals auf der Grundlage des Betrags des "Echtzeit"-Signals;
eine Einrichtung, die auf das "Unwuchtsteuer"-Signal anspricht, um die Drehzahl der Trommel zu verringern und eine Beschädigung der Maschine durch Zentnifugalkräfte zu vermeiden, welche aus einer ungleichmäßigen Beladung resultieren, wenn di Trommel mit der Austreibgeschwindigkeit gedreht wird, **gekennzeichnet dadurch** daß die Einrichtung zur Erzeugung eines "Unwuchtsteuer"-Signals aufweist:
eine Einrichtung zum Mitteln (22) des "Echtzeit"-Signals, wobei die Zeitkonstante für die Mittelungseinrichtung (22) derart beschaffen ist, daß das ausgegebene "Mittelungs"-Signal im Verhältnis steht zu dem mittleren von dem Motor (18) während einer relativ geringen Anzahl von Drehungen aufgenommenen Strom;
eine Einrichtung zum Abziehen (24) des "Mittelungs"-Signals von dem "Echtzeit"-Signal, um ein "Unwucht-Drehmoment"-Ausgangssignal abwechselnder Polarität zu erhalten, dessen Amplitude im Verhältnis zu den Schwankungen des Motordrehmoments steht, welche aus den durch die Beladungs-Unwucht entstehenden Zentrifugalkräften resultiert; und
eine Einrichtung (28, 30, 32, 34), die auf die Amplitude des "Unwucht-Drehmoment"-Signals, welches eine vorbestimmte Größe (welche eine maximal zulässige Unwucht-Zentrifugalkraft repräsentiert) überschreitet, anspricht, um das "Unwucht-Steuer"-Ausgangssignal zu erzeugen.

2. Unwuchtsteuerung nach Anspruch 1, **dadurch gekennzeichnet**, daß die Einrichtung zum Erzeugen eines Unwuchtsteuer-Signals gebildet wird durch eine Einrichtung zum Gleichrichten (28) des "Unwucht-Drehmoment"-Signals zu einem Signal mit einer einzigen Polarität und zum Filtern (20) dieses Signals mit einer Zeitkonstanten, welche ein gemitteltes "Unwucht-Drehmoment"-Signal liefert, welches den Unwucht-Drehmoment-Strom über relativ wenige Umdrehungen der Trommel wiederspiegelt, sowie eine Einrichtung zum Erzeugen eines "Referenzsignals", dessen Betrag die maxiaml zulässige Unwucht-Drehmoment-Beladung repräsentiert, und eine Einrichtung zum Vergleichen (34) des gemittelten "Unwucht-Drehmoment"-Signals und des Referenzsignals zum Erzeugen des "Unwucht-Steuer"-Signals dann, wenn das gemittelte "Unwucht-Drehmoment"-Signal das Referenzsignal übersteigt.

3. Unwuchtsteuerung nach Anspruch 1, **dadurch gekennzeichnet**, daß die Einrichtung zum Mitteln des "Echtzeit"-Signals einen Operationsverstärker (22) aufweist; daß die Differenzbildungseinrichtung einen Differenzverstärker (24) aufweist, wobei das "Echtzeit"-Signal die eine Eingangsgröße und das "Mittelungssi-

gnal" die andere Eingangsgröße ist; und die Einrichtung zum Erzeugen des "Unwuchtsteuer"-Signals einen Vollweggleichrichter (28) und ein Tiefpaßfilter (20) aufweist, denen das abwechselnde Polaritat aufweisende "Unwucht-Drehmoment"-Signal zugeführt wird, um ein Gleichstrom-"Unwucht-Drehmoment"-Signal zu erhalten, welches über relativ wenige Umdrehungen der Trommel hinweg gemittelt ist, eine Einrichtung zum Erzeugen (32) eines Gleichstrom-"Referenz"-Signals aufweist, dessen Stärke die maximale Unwucht-Drehmoment-Last für den Motor (18) repräsentiert, und eine Einrichtung zum Vergleichen (34) des Referenzsignals mit dem gemittelten "Unwucht-Drehmoment"-Signal und zum Erzeugen des "Unwucht-Steuer"-Signals, wenn das gemittelte "Unwucht-Drehmoment"-Signal das "Referenz"-Signal übersteigt, aufweist.

4. Unwuchtsteuerung nach Anspruch 2 oder 3, **dadurch gekennzeichnet**, daß die Einrichtung zum Erzeugen eines "Referenz"-Signals ein an eine Quelle für eine feste Spannung angeschlossenes Potentiometer (82) aufweist, wobei das Ausgangssignal an dem veränderlichen Anzapfpunkt des Potentiometers so eingestellt wird, daß ein "Referenz"-Signal gewünschter Stärke geliefert wird.

5. Unwuchtsteuerung nach Anspruch 3 oder 4 **dadurch gekennzeichnet**, daß die Unwuchtsteuerung außerdem aufweist, einen zweiten Operationsverstärker (26), der zwischen dem Differenzverstärker (24) und dem Vollweggleichrichter (28) liegt, um das "Unwucht-Drehmoment"-Signal zu verstärken, wobei der zweite Operationsverstärker (26) eine Filter-Rückkopplung (62, 64) aufweist, um aus dem "Unwucht-Drehmoment"-Signal Signale mit einer Frequenz zu eliminieren, die wesentlich höher ist als die Frequenz der Verteilungsgeschwindigkeit.

6. Unwuchtsteuerung nach irgendeinem vorhergehenden Anspruch, **dadurch gekennzeichnet**, daß die Trommel (11) sich um eine horizontale Achse dreht, die Hauptsteuerung (12) und die Elektromotor-Antriebseinrichtung (18) die Trommel (10) mit einer Drehzahl drehen, die etwa 0,7 "g" für die in ihr befindliche Ladung erzeugt, wodurch die Ladung zur Erleichterung der Waschwirkung reversiert wird, um dann automatisch die Trommel (10) auf eine Verteilungsgeschwindigkeit zu beschleunigen, die eine Belastung von annähernd zwei "g" während einer begrenzten Zeitspanne erzeugt, und die Drehung der Trommel (10) weiter auf eine Drehzahl beschleunigt, die eine Belastung von einigen "g" für das Austreiben des Hauptanteils der Flüssigkeit aus der Beladung erzeugt; und weiterhin **dadurch gekennzeichnet**, daß das Referenzsignal so eingestellt wird, daß ein zulässiges Unwucht-Drehmoment auf einen Wert begrenzt wird, der während der Anfangsbeschleunigung der Trommel (10) erkennbar ist.

Revendications

1. Dispositif pour maîtriser le balourd d'une machine à laver, comprenant : un tambour perforé (10) dans lequel des produits sont placés pour les laver, un moyen d'entraînement par moteur électrique (18) pour faire tourner ledit tambour (10) ;

un moyen formant commande principale (12) de ladite machine, comportant un moyen pour commander ledit moyen d'entraînement électrique (18) et la rotation dudit tambour (10), incluant un moyen pour accélérer la rotation dudit tambour (10) jusqu'à une vitesse de rotation relativement élevée pour l'extraction, par la force centrifuge, du liquide hors des produits qui s'y trouvent ;

un moyen pour obtenir, à partir du moyen d'entraînement par moteur électrique (18), un signal d'intensité en "temps réel" proportionné à l'intensité tirée par ledit moteur (18), ledit courant étant, à son tour, proportionné au couple nécessaire pour faire tourner le tambour (10), la demande de couple pour le moteur (18) variant cycliquement en proportion du déséquilibre de la charge à l'intérieur du tambour (10) en rotation et des forces centrifuges ainsi produites ;

un moyen pour produire un signal de "maîtrise de balourd" basé sur l'amplitude dudit signal "en temps réel" ;

un moyen sensible audit signal de "maîtrise de balourd" pour réduire la vitesse de rotation dudit tambour, pour empêcher des dommages à la machine provoqués par les forces centrifuges résultant d'une charge déséquilibrée lorsque le tambour tourne à une vitesse d'essorage ; et caractérisé en ce que ledit moyen pour produire un signal de "maîtrise de balourd" comprend :

un moyen pour faire la moyenne (22) dudit signal "en temps réel", la constante de temps dudit moyen pour faire la moyenne (22) étant telle que la sortie du signal "moyen" est proportionnée à l'intensité moyenne tirée par le moteur (18) pendant un relativement petit nombre de rotations ;

un moyen pour différencier (24) ledit signal

"moyen" dudit signal "en temps réel" pour donner un signal de sortie de "couple de déséquilibre" de polarité alternative, dont l'amplitude est proportionnée aux variations de couple moteur résultant des forces centrifuges produites par le déséquilibre de charge ; et

un moyen (28, 30, 32, 34) sensible au fait que le signal de "couple de déséquilibre" dépasse une valeur prédéterminée (représentant une force centrifuge de déséquilibre maximale admissible), pour produire ledit signal de sortie de "maîtrise de balourd".

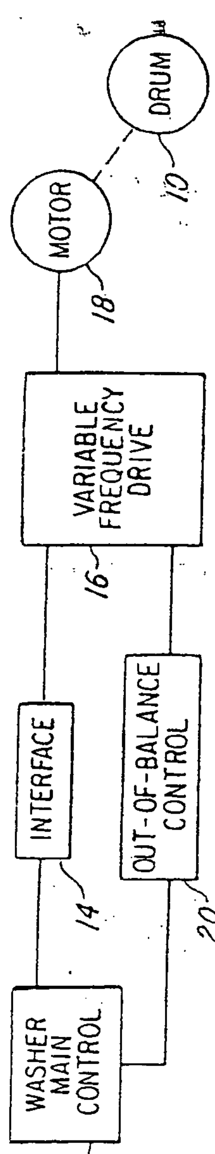
2. Dispositif de maîtrise de balourd selon la revendication 1, caractérisé en ce que le moyen pour produire un signal de "maîtrise de balourd" est constitué d'un moyen pour redresser (28) le signal de "couple de déséquilibre" en un signal de polarité unique et pour filtrer (30) ledit signal avec une constante de temps fournissant un signal de "couple de déséquilibre" moyen reflétant l'intensité de couple de déséquilibre sur un relativement petit nombre de révolutions du tambour ; un moyen pour produire un "signal de référence", dont l'amplitude représente la charge de couple de déséquilibre maximale à autoriser ; et un moyen pour comparer (34) le signal de "couple de déséquilibre" moyen et le signal de référence et pour produire ledit signal de "maîtrise de balourd" lorsque le signal de "couple de déséquilibre" moyen dépasse le signal de référence.

3. Dispositif de maîtrise de balourd selon la revendication 1, caractérisé en ce que le moyen pour faire la moyenne du signal "en temps réel" comprend un amplificateur opérationnel (22) ; en ce que le moyen pour différencier comprend un amplificateur différentiel (24), ledit signal en "temps réel" étant une entrée de celui-ci et le "signal moyen" étant son autre entrée ; et en ce que le moyen pour produire un signal de "maîtrise de balourd" comprend un redresseur à deux alternances (28) et un filtre passe-bas (30) auquel le signal de "couple déséquilibre", de polarité alternative, est délivré pour fournir un signal de "couple de déséquilibre" en courant continu sur un relativement petit nombre de révolutions du tambour, le moyen pour produire (32) un signal de "référence en courant continu" ayant une valeur représentant la charge de couple de déséquilibre maximale sur le moteur (18), et un moyen pour comparer (34) ledit signal de référence et ledit signal de "couple de déséquilibre" moyen et pour produire ledit signal de "maîtrise de balourd" lorsque le signal de "couple de déséquilibre" moyen dépasse ledit signal de "référence".

4. Dispositif de maîtrise de balourd, selon la revendication 2 ou 3, caractérisé en ce que le moyen pour produire un signal de "référence" comprend un potentiomètre (82) connecté à une source de tension fixe, la sortie de la prise variable du potentiomètre étant réglée pour donner un signal de "référence" d'une intensité souhaitée.

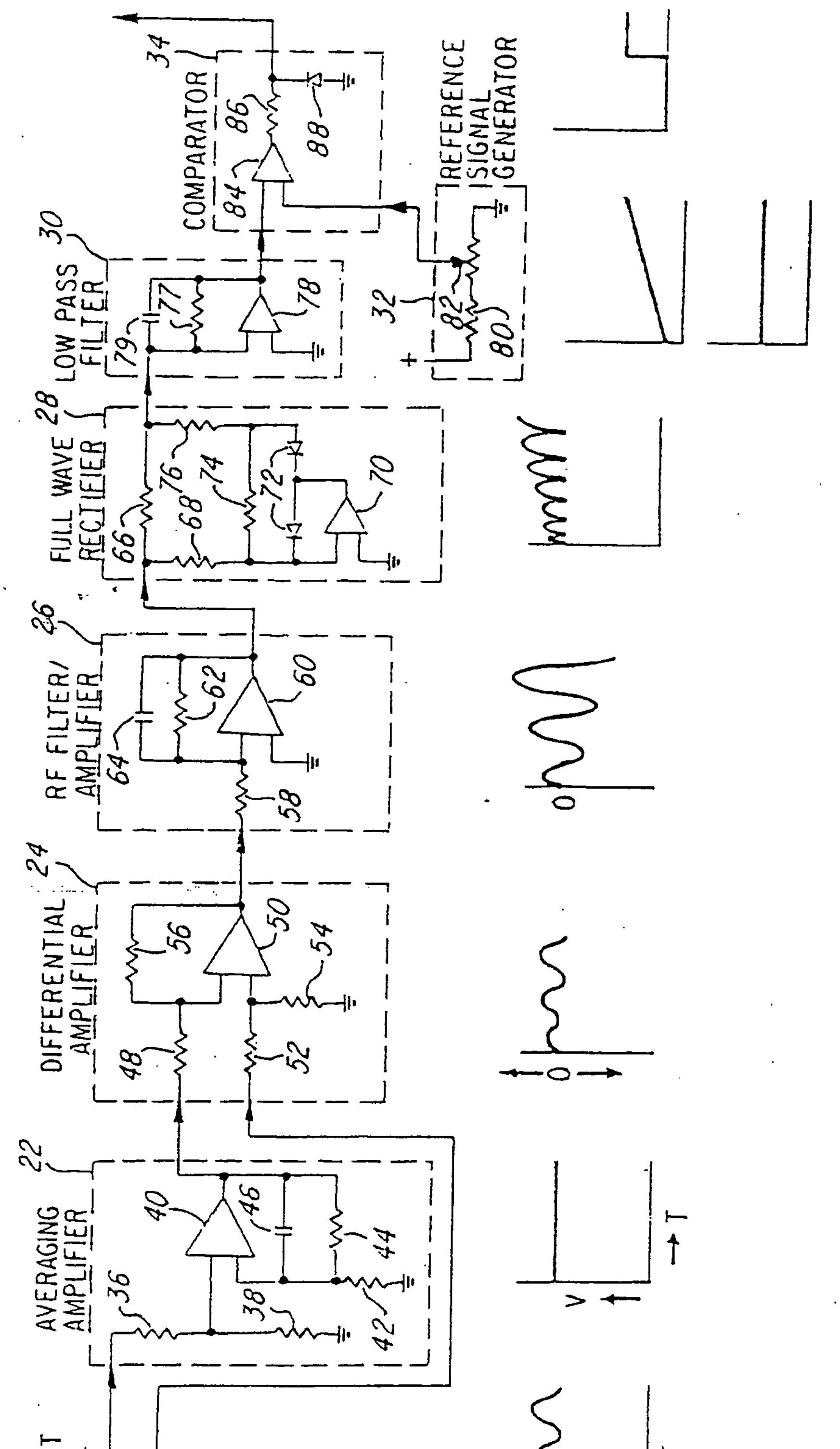
5. Dispositif de maîtrise de balourd selon la revendication 3 ou 4, caractérisé en ce que le dispositif de maîtrise de balourd comprend en outre un second amplificateur opérationnel (26) interposé entre l'amplificateur différentiel (24) et le redresseur à deux alternances (28), pour amplifier le signal de "couple de déséquilibre" ; ledit second amplificateur opérationnel (26) ayant une contre-réaction par filtre (62, 64) pour éliminer, du signal de "couple de déséquilibre", les signaux d'une fréquence sensiblement plus grande que la fréquence de la vitesse de répartition.

6. Dispositif de maîtrise de balourd selon l'une quelconque des revendications précédentes, caractérisé en ce que le tambour (10) tourne autour d'un axe horizontal, en ce que la commande principale (12) et le moyen d'entraînement par moteur électrique (18), pendant un cycle de lavage, font tourner le tambour (10) à une vitesse produisant environ 0,7 "g" sur la charge qui y est contenue, ce par quoi la charge est culbutée pour faciliter l'action de lavage, puis, pendant une période de temps limitée, accélèrent de manière automatique ledit tambour (10) jusqu'à une vitesse de répartition produisant une charge d'environ deux "g", et ultérieurement accélèrent la rotation dudit tambour (10) jusqu'à une vitesse produisant une charge de plusieurs "g" pour l'extraction de la majeure partie du liquide de ladite charge ; et caractérisé en outre en ce que le signal de référence est réglé pour limiter le couple de déséquilibre admissible à un niveau détectable pendant l'accélération initiale du tambour (10).



WASHER MAIN CONTROL
12
INTERFACE
14
OUT-OF-BALANCE CONTROL
20
VARIABLE FREQUENCY DRIVE
16
MOTOR
18
DRUM
10

FIG-1



MOTOR CURRENT SIGNAL
AVERAGING AMPLIFIER
22
36
38
40
42
44
46
DIFFERENTIAL AMPLIFIER
24
48
50
52
54
56
RF FILTER/ AMPLIFIER
26
58
60
62
64
FULL WAVE RECTIFIER
28
66
68
70
72
74
76
LOW PASS FILTER
30
77
78
79
COMPARATOR
34
84
86
88
REFERENCE SIGNAL GENERATOR
32
80
82
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FIG-2